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ABSTRACT

This is a model technology course which offers a starting point for those administrators and prospective instructors who need ideas about the nature of a course to teach technology to non-technologists. This course is based on the premise that technology should be taught as part of the liberal arts or general education core at the undergraduate college level. The primary purposes of this course are to help college students prepare to live and work in a technological society, understand how technology is developed, how it affects their lives and institutions, and how it can be directed. The course has been constructed around four foci: history, systems, impacts, and futures. Suggested activities are included in each of the four sections to help the reader/instructor identify useful ways of engaging students in productive learning experiences. An annotated bibliography is also included in each section to assist in the selection of excellent supportive readings and multimedia materials. (JRH)

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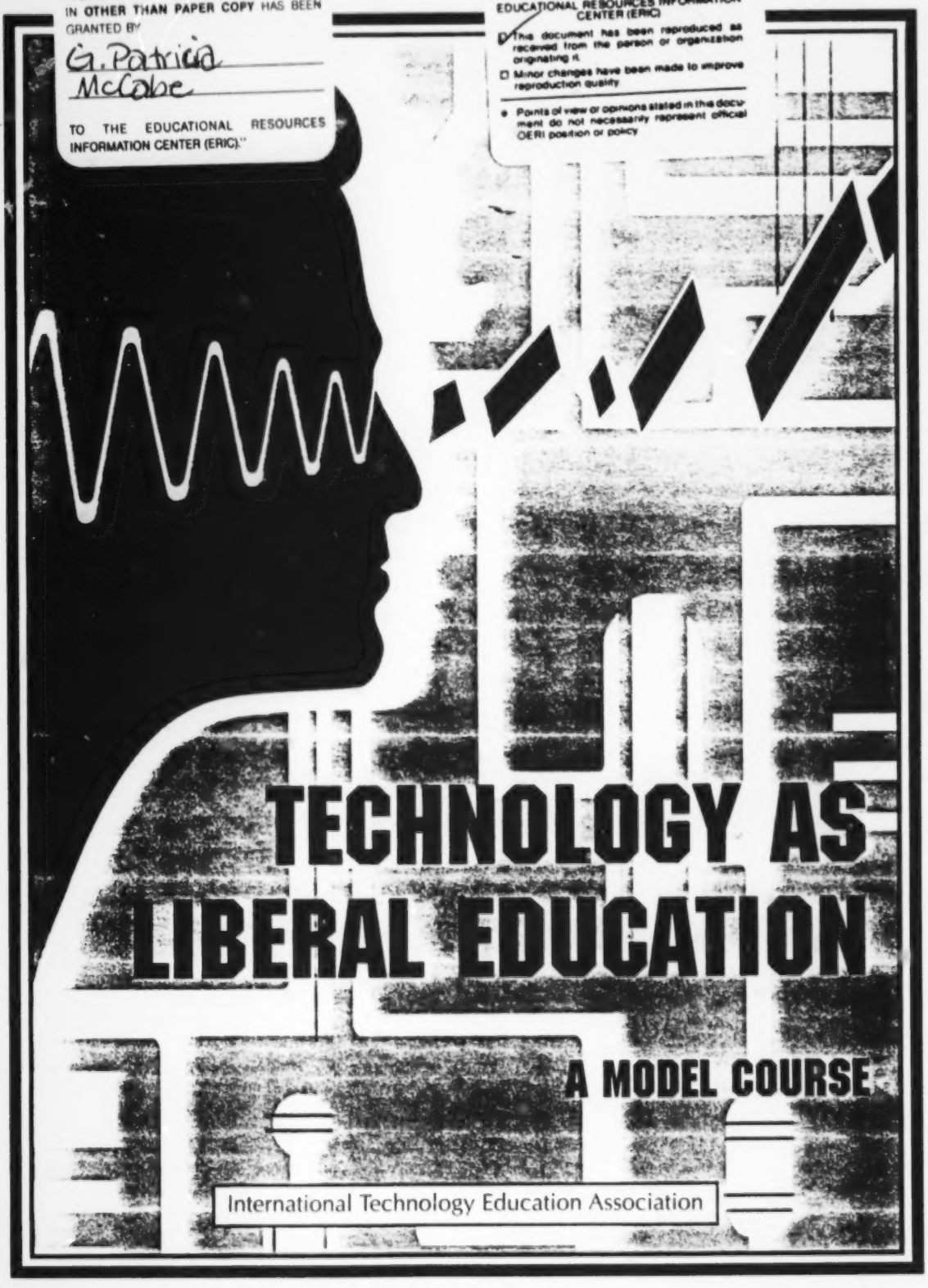

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TECHNOLOGY AS LIBERAL EDUCATION
A MODEL COURSE

A Monograph Proposal to
The Publications Committee of
International Technology Education Association

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PREFACE

In 1989, the International Technology Education Association (ITEA) established a Task Force on Technology Education as Liberal Education to address ways of increasing the number of technology courses at the undergraduate level and to help identify the content of such courses. As a result of this mandate, a "model" course was developed by six members of the Task Force. This proposed course was presented at several conferences between fall, 1991 and spring, 1992--the Technology Education Symposium at Indiana State University, the Technology Literacy Conference of the National Association of Science, Technology, and Society (NASTS) in Crystal City, VA, and the ITEA Annual Conference in Minneapolis. The feedback from the participants at these conferences was helpful in the final work session held at the ITEA conference at Charlotte, NC in 1993. One of the additions to the course as a result of that meeting was a series of activities for each of the sections.

The reader is advised that the writers saw this course as "a" model course, not "the" model course. Its main purpose is to offer a starting point for those administrators and prospective instructors who need ideas about the nature of a course to teach technology to non-technologists. More comments will be made in the narrative relative to its use.

I want to thank the ITEA for establishing the Task Force and for their patient support. as we have developed and completed our agenda. A special thanks go to the writers who have worked diligently to develop and improve this manuscript these last two years. It has been an exciting experience to work with them. The participants in this project were:

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We encourage you to use what you can from this course. In a real sense, every good course is never finished. This is certainly true of courses in technology since the pervasiveness of the subject continues to expand, and the artifacts continue to accumulate. Without question, those of you who use some or all of this course outline will enrich it with your own contributions.

A. Emerson Wiens, Task Force Chairperson
Technology Education as Liberal Education
December 1993

INTRODUCTION

TECHNOLOGY AS LIBERAL EDUCATION

> But no adult is truly civilized unless he is acquainted with the civilization of which he is a member, and the liberal arts curriculum of fifty years ago no longer provides that acquaintance. The fact that it does not do so is reflected by the fact that one can no longer study even philosophy or history at a respectable scholarly level without some acquaintance with the modes of thought represented by analytic and technological skills.
> (White, 1981, p. 11)

It is the contention of the authors of this "model course" that technology should be taught as part of the liberal arts or general education core at the undergraduate college level. Before describing the contents of the course, a discussion of the meaning of the term "technology" and the rationale for such a course seems appropriate to assure that the writers and readers are beginning with the same conceptual framework.

Definitions[1]

Mitcham (1980) suggested that technology can be understood in five ways: as object, as process, as knowledge, as volition, and as either ancient or modern technology. Perhaps, at the most obvious and simplistic level, technology is seen as object. This includes artifacts, tools, machines, electronic devices, consumer products, and gadgets created by humans to fulfill some human need or want. Writers have attempted to classify technological objects by different criteria. Machines, for example, can be seen as active--applying laws of mechanics to help people do work, or passive--architectural structures, reservoirs, and canals. Mumford (1967) even argues that armies and the Egyptian workforce that built the pyramids could be considered a machine -- a "megamachine." As will be seen, definitions from technology educators include, but all go beyond, technology as object.

Technology as process can be viewed as designing or making artifacts, a focus of engineers, or as using artifacts, a focus of social scientists (Mitcham, 1980). The engineering approach includes identification of the problem, application of mathematics, and/or other appropriate problem-solving techniques and/or laws of science to the design. Engineering design, Mitcham states, "mediates between scientific knowledge and social exigencies" (1980, p. 308). In this sense, technological decisions must often be made without full knowledge of the impacts of a particular decision; for example, a doctor prescribing a certain drug which has been shown to have harmful side-effects in some patients, does not know what reaction may occur in advance.

The solution of an engineering problem is not always an artifact. For example, determining the queuing formula for regulating the traffic flow over the Oakland-San

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[1]Portions of this section are excerpted from Wiens, A.E. (1988). Chapter 10: Technology education as a part of undergraduate liberal education. Industrial Teacher Education in Transition, D.L. Householder, Ed., Mississippi Valley Industrial Teacher Education Conference.

Francisco Bay bridge or any other restricted traffic way, for that matter, does not result in an artifact. While traffic lights may be used to solve the problem, the technological solution is not the invention of the traffic light but the determination of the timing of the lights and the designation of in-going and out-going lanes at different times of the day.

The third view of technology--as knowledge -- is held by Skolimowski (1966). He states that understanding technological progress is the key to understanding technology. In the process of solving technical problems, knowledge is increased. Knowledge is the by-product, not the goal, but is precisely that by-product which will help solve the next technical problem from which new knowledge is gained. Hence, technological progress continues.

Technology as volition refers to the act of willing, of having purpose and direction; the act or faculty to will by which the resources available are directed toward a desired end. This can lead to questions regarding the broader implications of a certain technological process or artifact, or, more specifically, the social, political, economic, psychological, and/or ethical dimensions of the respective technology.

The concept of ancient versus modern technology relates to how an artifact is made and how close to nature the craftsman is. Mitcham (1980) explains the differences this way:

> Ancient technology incorporates individual objects fabricated with naturally available energies and materials on the basis of intuitive knowledge for the limited purposes of usefulness and pleasure within a variegated spectrum of activities. The ideal type for ancient or traditional technology is the hand-crafted making and using of utensils; as such, a better word for it might be "technics" (from the Greek techne) or "art." Modern technology, by contrast, involves mass-produced objects designed to utilize abstract energies and artificial materials on the basis of scientific theories for purposes of efficiency, power, or profit. (p. 322)

Looking at technology as object, as process, as knowledge, as volition, as ancient or modern, however interesting and informative, does not provide us with a concise working definition. Allan Pfnister refers to the intervening aspect of technology. He states, "It is a form of intervention that employs tools, techniques, knowledge, resources, and systems for the purpose of affecting the human environment and its organization" (1985, p. 11). Pfnister elaborated further on technology as being "preeminently a social process and is not to be thought of as something affecting humanity from without" (1985, p. 4).

Participants in the Jackson's Mill Industrial Arts Curriculum Theory Project defined technology education:

> . . . as the knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage the man-made and natural

environment for the purpose of extending human potential, and the relationship of these to indiviiduals, society, and the civilization process. (Snyder and Hales, p.2).

Both of these definitions are comprehensive in the sense that they include all four aspects: object, process, knowledge, and volition ("for the purpose of"). The same can be said of the following definition by Stephen Cutcliffe:

> Technology is a social process in which abstract economic, cultural, and social values shape, develop, and implement specific artifacts and techniques that emerge from the distinct problem-solving activity called engineering which is embedded in that process. (I981)

Despite the similarities in these three definitions, they were written for different audiences. The Jackson's Mill authors were writing primarily for the industrial arts (now technology education) profession; Pfnister and Cutcliffe were both seeking support for technology education in the liberal arts college curriculum. However, Cutcliffe's definition differs in two significant aspects from the other two; he gave much more attention to the milieu or context which affects technology; secondly, he gave a disciplinary locus to the study of technology, namely, engineering. The later point contrasts with Pfnister's desire to see technology taught as part of all the disciplines.

Rationale for a Technology Course in Liberal Education

The inclusion of the study of technology as part of liberal education or of a general studies core can be argued from several perspectives. As Custer (1990) noted:

> Certainly, technology has not erased the ancient questions about truth, beauty, reality, and a person's relationship to them. Technology, however, has significantly altered the context in which these questions are posed.... Nothing has changed the purpose of liberal education. What has changed tremendously is the cultural context for liberal education. (p. 51)

This view has been shared by other's as well. Stephen White was basically responsible for directing a substantial amount of the Sloan Foundation's efforts and money into collegiate level technology courses for non-technologists in what became known as the New Liberal Arts Programs. In the statement at the opening of this section, he reflected on the reason that Sloan got involved in encouraging technology courses for all undergraduates.

Hence, technology courses in the liberal arts core would help college students understand the dynamic culture in which they live. But such courses also have more immediate and pragmatic values. Bugliarello (in Krieger, 1987) expressed the need for technological literacy courses in the liberal arts with a degree of urgency when he wrote:

> We are a nation of technological illiterates, at risk in industry, in defense, and indeed in our culture. If we are to maintain our competitive position in the world, technological literacy must be accorded top national priority. (p. 27)

Friedman (1980), like Bugliarello, tied the need for technology education to the fate of our country:

> For me, the most compelling reason for technological literacy is the survival of the democratic process .... Judgments concerning resources of our nation need to be made by an informed citizenry. Luddism will only strengthen the hand of the technocrats. The issues stretch from MX missile deployment to space travel, and we, as a nation, are not prepared for participatory decision making. We need to confront these problems with the vast intelligence that they require. (p. 2)

Perhaps no stronger case can be made for a technologically literate citizenry than this. As educators, we need to make this case. The evidence seems clear that we are loosing ground due in large measure to an educational system that has failed to prepare our citizens for life in the waning decade of the 20th century and the beginning of the next. According to several measures, the quality of life in the United States is no longer number one in the world. There is little security in military strength if our balance of trade shows perennial deficits, if increasing amounts of our assets are being owned by foreign parties, if our product quality can no longer compete internationally, and if many of our youth do not have the skills or knowledge to help our industries succeed, to feel secure in this technological world, or make a contribution to society.

In summary, five points can be made for the inclusion of technology courses in undergraduate education:

1. The survival of life as we know it depends on our understanding of not only how technology works but also of what the cultural and environmental effects are of its uses. The decisions that must be made are too important to our survival to leave to the specialists whose narrow training and vested interests may prevent them from seeing the whole consequence of their actions. Bensen (1986) states the situation like this:

> Never before have we had the "tools" to create, develop, and attain our ultimate destiny. But even now, to do so will require an openness to new educational proposals. At the center of such educational plans must be the inclusion of the study of technology. (p. 27)

2. Closely related to the first point is the need for a technologically literate citizenry for the welfare of a representative form of government. All citizens are expected to participate in the decision-making processes which allow our country to function for the greatest welfare of its citizens and to compete internationally. The influence they bring to bear will be based on knowledge and understanding or on ignorance. Truxal (1986) expressed the need in these words:

> . . . it [the teaching of technology] should not be restricted to students who will be future leaders; most of our students do not fall into this category. As educators, we hope graduates will contribute to the healthy development of society through their individual creativity, their relations with family and friends, their jobs, and their roles as citizens. In each of these directions, the individual interacts with a highly

technological environment; education should develop capabilities for lifelong learning in all of the disciplines that contribute to that environment. (p. 1)

3. The work force in this country needs people who can understand technology and have the "tools" to solve technical problems. Educating the workforce serves individuals as well as society at large. Nearly every occupation today interfaces with technology in one way or another. As Carrel (1987) indicated, different occupations require different levels of technological literacy. Nevertheless, the labor force at all levels needs to be prepared for a technological world. The current challenge to our world leadership in technology should serve as a mandate to the inclusion of technology education for all students.

4. The fullness of our human experience depends on our ability to feel at home in a technological world. Technology needs to be understood for what it is: neither a god to be worshipped nor an evil to be scorned or feared, but a tool to be used for enhancing life. People who do not understand technology often feel intimidated and controlled by technology. This need is addressed in the description of the program in technology for liberal arts students at SUNY, Stony Brook:

> The broad educational goal of this Department is to give all students the self-confidence that they can learn a particular technology when the need arises, the realization that such learning is personally rewarding, and the awareness that the development of technology can be controlled by the public. As Bob Wheeler of Yale has repeatedly emphasized, we above all want to teach our students to be nonsense-detectors--to question simplistic arguments (whether pro- or anti-technology) and to view issues from a broad, non-disciplinary vantage point. (Truxal and Visich, 1987, p. 27)

5. While one may be convinced that a need exists for technology education, one might ask why it is necessary at the collegiate level. Certainly, a sound education in technology in the elementary and secondary schools should be mandatory for all students for the reasons elaborated above, especially since not all students attend college. Currently, however, no standardized curriculum exists nor has a national commitment for including technology education at the secondary level been adopted. Even if a sound technology education did exist in the public schools, the need for a baccalaureate course would still exist since the complexity of the technology/society interface is better understood by students with more intellectual maturity. Baccalaureate level education about technology is as justified as other baccalaureate level liberal arts/general education courses. Given that our country relies heavily on college-educated citizens for its leaders, technology education is imperative at this level.

Historically, courses <u>about</u> technology have often been taught in the liberal arts curriculum where the negative effects of technology were the focal point. It is imperative that technology be taught from a more objective point of view in which the negative aspects are balanced with the life enriching contributions of technology, and in which the central focus is the role of human beings interacting with and controlling technology.

Goals for a Technology Course at the Baccalaureate Level

Given this rationale for having all students take a technology course at the baccalaureate level, what should be the goals of the course? In short, the primary purposes of the course are to help college students prepare to live and work in a technological society, understand how technology is developed, how it affects their lives and institutions, and how it can be directed. The five arguments noted above describe the broad goals for this course. Additional goals of the course are:

1. To reduce the fears and misunderstandings about technology; to help students discover that learning technology can be interesting and fun.

2. To assist students in thinking about technology. Most people use technology but give little thought to its development. Students should be encouraged to ask and answer "why then" or "why now"? For example, why were inventors in several countries simultaneously working on developing an automobile in the 1890's (why then)? Or why is the FAX machine growing in popularity now when a version two decades back would not catch on (why now)? Viewing technology development in this manner helps one to understand the past, explain the present, and anticipate the future.

3. To enable the students to give examples of modern technology as pervasive, not being neutral, centralized and powerful, creating artificial environments, involving systems, and having a great influence on their future culture, environment, and careers.

4. To help students understand the interactive nature between human values and technological development and acceptance, and to introduce students to techniques for predicting the social and environmental effects of adopting a given technology.

5. To provide the opportunity and support for students to apply a new (to them) technology in a problem-solving situation. While many technology educators assume that one cannot understand technology unless one has "hands-on" experiences with tools and artifacts, such a view denies the premise that technology is a social process and includes problem-solving processes such as timing traffic lights and designing hydroelectric plants or computer networks.

6. To assist students in becoming "nonsense-detectors"; to encourage the coupling of basic technical knowledge and rational objectivity in determining the truth regarding media reports about technology and its use.

7. To enable students to (a) describe the historical and present relationship between science and technology, (b) explain the differences in purposes and approaches between science and technology, and (c) to give examples how these two areas develop independently and interdependently.

How to Use This Material

The reader is reminded that this is "a" model course, not "the" model course. It is offered as a guide for those educators charged with developing a course on technology

for general studies, particularly for non-technologists. However, the course would be an important addition in many technical major programs where specialization excludes a broad-based contextual view of technology in society.

The course as presented has four foci; history, systems, impacts, and futures. These four organizers were selected after considerable discussion regarding the best ways to approach the teaching of technology. While the writers believe that these topics are important and defensible in the study of technology, they recognize that other curriculum developers may select other organizers and find them equally or more compatible for their purposes. Each of the four sections is sufficiently developed to provide the reader/instructor with a grasp of the important concepts within each section.

Human history is basically a history of humankind's development of adaptive systems which are technological in nature. Human progress as it is usually defined, is dependent on developing technology. The history section includes a discussion of the factors which are necessary before a given technology can be developed, the factors that explain the "why then" question. This section also debunks some of the commonly held myths about technology in history.

Everything in our society can be viewed as operating as part of one or more systems. One of the major systems in our society is the technological system which can be described at both the macro and micro levels. Students are encouraged to modify or remove one part of a system in order to gain a greater understanding of the interdependence of the parts of the system.

Technology is a major factor in social, cultural, and environmental change. Some educators oppose the use of the term "impacts" because of the connotation of unidirectionality and the over-simplification of the complex relationship between technology, society, and human interaction. However, the writing team decided to use the term "impacts" because of its common use and acceptance. The narrative in the impacts section clearly discusses the nature of the interactive relationship between society, values, and technology development and acceptance. In this section, students should also consider the implications of technology use on the world environment and should be challenged to consider personal commitment as well as the need for political cooperation and action in order to develop a sustainable future.

The futures section begins by engaging the students in goal setting activities which are used to illustrate the need for planning technological futures. The students are also introduced to projection techniques which are increasingly important as humankind attempts to control the harmful consequences of certain technologies.

These course materials are designed to be versatile. With their help, a course could be organized and taught in one of three ways:

1. The text could be used as it is to teach a course organized around the four general topics, i.e., history of technology, impacts, technological systems, and futures.

2. A separate course could be taught on any one of the four topics.

3. These four topics could be used as a technique for studying a specific technological
field or artifact. A table is provided in the text that shows how this could be done for a study of the computer or of genetic engineering. In such a course the technology becomes the focal point, and the history and development, interaction (impacts) with society, place within macrosystems and use of microsystems, and the future effects on society are all studied in respect to the chosen technology.

Suggested activities are included in each of the four sections to help the reader/instructor identify useful ways of engaging students in productive learning experiences. An annotated bibliography is also included in each section to assist in the selection of excellent supportive readings and multimedia materials.

This course will always be changing and will benefit from reader/instructor development and suggestions. Are the four organizers chosen an effective way to study technology? Certainly there are other organizers and approaches that are also effective. Which activities have proven to be successful teaching aids? The reader/instructor is encouraged to experiment and share his/her experiences with the profession.

Best wishes for an exciting teaching experience!

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Technology in History

Technology as History

The history of technology is the history of humankind. Without technology we would not have a recorded history. How does one record history, or anything else for that matter, without communication technology? In fact, if humans had not developed technology we probably wouldn't have a history to record. Humans are one of the weakest species to survive, and without our thinking brain to create technologies to make us stronger, faster, able to see and hear great distances, use tools and weapons for survival, etc., we would be extinct.

Yet when we study history in our classrooms we study about the discovery, colonization, rise and fall of nations, and their politics, wars, revolts and revolutions. Of course there were political, societal, and cultural reasons for these occurrences, but why just study those reasons? That type of history course is analogous to studying the shape, color and texture of a cake to find out why it tastes good, rather than studying the ingredients in the cake's recipe. Rarely, if ever, do we discuss the technologies that were often the reason for the success or failure of those nations, wars, revolutions, etc.

If the evolution of technology was included as a major ingredient in our study of history, students would become aware of the impacts that changing technologies have had on the development of our nations, our societies, and our cultures. They would be able to understand that the possession of, or the lack of possession of, a particular technology at a particular point in time significantly altered the course of a particular society, sometimes for the better, and sometimes for the worse. They would be able to see what the implications were of a particular invention on a particular society. They would discover why one particular society dominated the civilized world when it did and why it fell to the next dominant society. They would discover that the reasons often included the state of the arts of the technologies within the involved societies, in addition to or in spite of the then current political situation.

What of the role of science in technological development? Why did we, how could we, have technology before science? How do they differ? When were they developed? Why? By whom? The answers to these and similar questions will add to the holistic education of all students and provide them with a richer and fuller understanding of the history of world society and culture.

History of Invention

We all have heard the statement that "necessity is the mother of invention." Few of us would question this statement. Yet it becomes very apparent when studying the history of invention and innovation that there are many other equally important reasons why these phenomena occur. Sometimes inventions and innovations are made for the wrong reasons or needs. War technology, for example, can be justified by some because of all the "helpful" spin-offs that can result from this type of technology. Sometimes large amounts of money are given to develop wanted (not necessarily needed) technology at what some people perceive to be the wrong time. For example, the star wars defense

system and the space station are two examples of technological innovation and invention where vast amounts of money are being allocated while critical social problems go un- or under-funded.

The reason for bringing up these controversial issues is not to debate who is right and who is wrong, but to make the point that these types of controversial issues are not unique to our current time of the 20th century. Government support for, or its lack of support for, technological development has been an issue since there have been governments. Government support for virtually all of our production, transportation and communication systems, as they have evolved throughout history, have been debated and sought to be restricted by one group or another, for reasons that often had little or nothing to do with the technology itself. The historical decisions made regarding these issues and their resultant impacts on society can and should be used as examples when debating today's technological issues.

In addition to the politics related to innovation and invention, there are a number of other seemingly unrelated forces that influence what, when, and where something is invented. Economic forces, for example, can be a major contributor to whether or not a technological idea is researched and developed. We can only wonder how many inventions and ideas were lost, perhaps forever, during the U. S. depression era of the 1930's. Social pressures also can be extremely influential, especially when decisions are to be made about ecological, biological and environmental technologies.

Connections in History

The history of technology is full of points in time when the development of a particular technology stimulated a virtual explosion of other technological developments. These key technologies are also known as foundational technical developments because they were the basis for a vast array of new technologies. They serve as the connections between many otherwise seemingly unrelated technological developments. As Burke's video series and text Connections so clearly point out, these critical technologies occurred throughout the history of humankind and throughout the world. No society or time period had or has a monopoly on these super technologies.

However, there have been periods of time during which certain societies seemed to pull far ahead of the rest of the world. The reasons for these spurts were both technological and social. The two systems seem to feed on each other, creating a super society. The Greek and Roman societies are examples from ancient history and the English Industrial Revolution is an example from more recent times.

An interesting way to study the connections and linkages between selected technologies is by conducting lineage studies. These studies reveal the state of the art of the various related technologies that were necessary for the new technology to have been invented, innovated, or developed. When a number of such studies are conducted, they will often reveal a common artifact that was foundational in each of the studied technologies. Examples of foundational technical developments are gearing, the cam, the vacuum pump, and the transistor.

Technological Myths in History

Many myths exist about and within the history of technology. For example many persons believe that technology is a product of western civilization. Nothing could be further from the truth. The earliest known humans, beings that walked upright and began to develop technology, lived in Africa. When humans developed sufficient technology to become sedentary, they created civilizations in what are now Iraq and Egypt. Some of our most important technological developments--paper, gunpowder, compass, rockets, steel, stirrup, moveable type--all can be traced back to the ancient civilizations in China, Japan, Korea, and India. The western world, in later times, often reinvented, improved upon or made better use of many of these items, but inventions and related technologies are common to all parts of the world, not just the Western societies.

Another technological myth is that invention can happen out of nothing. This myth probably evolved because some technological developments were discovered, rather than invented, in that the technology created was not the one for which the inventor was trying. Macintosh, for example, discovered the use for the sap from rubber trees while searching for a way to produce cheap naphtha. Moissan was trying to make artificial diamonds when he discovered the process for making acetylene gas. But the truth is that invention, innovation, and even discovery come only to those who first thoroughly research the state of the art in which they are working, and then spend many, many hours seeking a solution to their problem. Even though they sometimes come up with something totally different than what they were looking for, the ability to recognize the value of their creation requires expert knowledge of the area under study.

A definition of technology commonly used outside the field of study is "applied science." This definition implies that there must be scientific understanding before a technology can be developed. Again, nothing could be further from the truth. Literally thousands of technologies have been developed and used for centuries before we have learned their underlying scientific principles. Science, as we understand the term today was not even established as a formal activity until the 17th century. By that time the world was full of technology.

Finally we come to the myths related to inventors themselves. Throughout the centuries, hundreds of inventions, innovations, and discoveries have been credited to persons who really did not deserve that distinction. Sometimes this happened because the person simply stole the invention from the true inventor. Sometimes the person was credited with the invention because he or she was the financial backer of the invention. Sometimes society, over time, awarded the invention to someone who perhaps was associated with the technology, but didn't really do the inventing.

While this type of myth is usually not harmful, would you feel comfortable if Lewis and Clarke were depicted in school history books as the discoverer of the Pacific Ocean, Lincoln as father of our country, or Franklin Roosevelt as the person who ordered the dropping of the atom bomb on Hiroshima? Of course not. You would demand that the record be set straight. The same holds for technologists. Our children need to know that

Ford did not invent the automobile, Fulton did not invent the steam boat, and Watt did not invent the steam engine.

History Section Outline

Rationale for Studying History of Technology
- Without Technology, No Humans
  - Discuss the opposable thumb and its relationship to technology development and the use of technology
- Without Technology, No History
  - Review the ways that communication technology contribute to the recording of technology
- Causes of Political Change Often Found in Technological Advantage
- Relationship between Science and Technology

History of Invention
- Triggers of technological Change
  - Need
  - Religion
  - Warfare
  - Accidental discovery
  - Deliberate research
  - Environmental change
  - Transfer of knowledge; spin-offs
- Government Support Debate
- Other Reasons for Invention
  - Ideology and fear
  - Politics: prestige and power
  - Influence of regional/national resources and geography

Connections in History
- Foundational Technical Developments
  - Super technological developments spur the development of many other technologies
- Time and Place Connections
  - Foundational technological developments at the right time in the right society create super societies
  - Simultaneous technological developments
    - Same time, different part of country
    - Same time, different countries
- Lineage Studies
  - Identification of foundational technical developments
  - Researching connections

Technological Myths in History
- Technology is a Western Development

- Technology has been a world phenomena since the beginning of technological development

Invention Can Happen From Nothing

- Accidental discovery still based on understanding what has happened
- Innovation/invention only come after conducting extensive research into problem; then comes Eureka!

Technology is Applied Science

- Many technologies existed centuries before we understood the scientific principles
- Modern science is a 17th century phenomenon

Crediting the wrong person with an invention

- See Watt, Ford, Bessemer, Singer, Fulton, etc.
- Many inventions invented by more than one person at relatively the same time at different places

Activities

1. Prepare a biographic sketch of one inventor or innovator who contributed a major technical development to the advancement of civilization. (biographical sketch)

2. Conduct a terminological study to identify, define, and illustrate the use and derivative of a technological term, its changes in definition, use, spelling, etc., over time, and describe its present use in technical literature. (terminology study)

3. Select from the reservoir of technological data one significant technical development and trace its lineage, determining the reservoir of knowledge necessary for the development to take place and describe verbally and graphically the lineage of the innovation or invention and its technological significance, i.e., its impact on society at the time of its invention. (lineage study)

4. Research, describe, assess and restore (or develop a working model of) one artifact of historical significance from a given area of technology by following acceptable historical research techniques. A written description of your research findings and restoration (or development) procedures also should be developed. (technical restoration study)

5. Conduct a recorded oral historical investigation of a specific problem in one area of technology using acceptable interview techniques. A transcription as well as the original tape(s) should be submitted. (oral history study)

6. Develop a comprehensive, annotated resource file for teaching the History of Technology in a public school system. Include titles and sources for:

a. films
b. charts
c. models
d. artifacts
e. bibliography
f. museums
g. other

NOTE: The three central technological themes, namely transportation, communication and production must be represented. (resource study)

7. Conduct a case study of one technical development. Describe, by appropriate means, the nature of the innovation or invention, its evolution over time, a description of how it works (current), the social, cultural, economic and political conditions of the time of its invention and their impact on the development or vice versa, and its current status in society. (case study)

Activities numbered 1, 2, and 5 are recommended as individual student projects. Activities 3, 4, 6, and 7 are recommended as individual or group projects.

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Impacts

Technology and Social, Cultural and Environmental Change

The creation of technology is a fundamental feature of human society, and its use determines the way in which we interact with each other and nature. Perhaps equally important but less obvious is that technology is a product of social, cultural, economic, and political actions. The technologies found in a particular society exhibit the nature and organizational structure of that society. The study of technology is therefore important for what it reveals about the society and culture humankind has made for itself.

Technology is increasingly viewed as a defining characteristic of contemporary life. Historically, the use of tools, artifacts and various processes have always distinguished humans from other species. In fact, by their use, humans have moved through one stage of cultural evolution to another. Until quite recently the process of change was gradual. However, over the last two centuries, the application of scientific and technological knowledge has transformed the intellectual and materialistic conditions of life.

Humans now depend on various technological systems to meet numerous human needs. These include the needs for food, clothing, shelter, health, security, education, communication, transportation, meaningful work and leisure. It is understandable that in thinking about various technological systems one habitually focuses on the technical hardware rather than the human activity. This is generally true because the various artifacts and systems of technology are seen as a measure of progress. Examples of such progress might include the compass, pump, printing press, steam power and electrical generation.

Yet, there are inherent problems in viewing such artifacts and systems as progress. Contradictory attitudes have developed as a result of the consequences of technology. As the rate of social change accelerated, there has been a questioning of the pervasive impacts of technology. This is particularly true with regard to the moral, psychological, social, environmental and cultural effects of technology.

The concern being expressed is that the accelerated growth of technology is out of control. This growth can be attributed to the increases in research and development budgets, financial pressures associated with research and development, the introduction of new tools and processes within the production sector, the need to stay competitive in the marketplace, and the ever increasing diffusion of knowledge. Durning (1991) illustrated this acceleration of technology by reviewing various goods and services provided by industry:

> Skyrocketing consumption is the hallmark of our era. The headlong advance of technology, rising earnings, and consequently cheaper material goods have lifted overall consumption to levels never dreamed of a century ago. The trend is visible in statistics for almost any per capita indicator. Worldwide, since mid-century the intake of copper, energy, meat, steel and wood has approximately doubled; car ownership

and cement consumption have quadrupled; plastic use has quintupled; aluminum consumption has grown sevenfold; and air travel has multiplied 32 times. On average people today own twice as many cars, drive two-and-a -half times as far, use 21 times as much plastic, and travel 25 times as far by air as did their parents in 1950. Air conditioning spread from 15 percent of households in 1960 to 64 percent in 1987, and color televisions from 1 to 93 percent. Microwave ovens and video cassette recorders found their way into almost two thirds of American homes during the eighties alone. (P. 154)

As a result of this accelerating growth of technology, society has lost its ability to effectively manage the technical means being implemented (cf. Cousins, 1945; Engle and Longstreet, 1978). Such a loss of control has important implications for society. Therefore, it is necessary for all citizens to understand the social context from which technology operates. This social context maintains five major domains of activity:

1. The Human Need Domain - These include the wants, needs and desires of humankind and the societal and environmental problems resulting from the industrialized nature of society.

2. The Ideological Domain - This domain of activity reflects the goals, values and ethical considerations of a society. Within this domain are the beliefs of sustainability, equality and social justice.

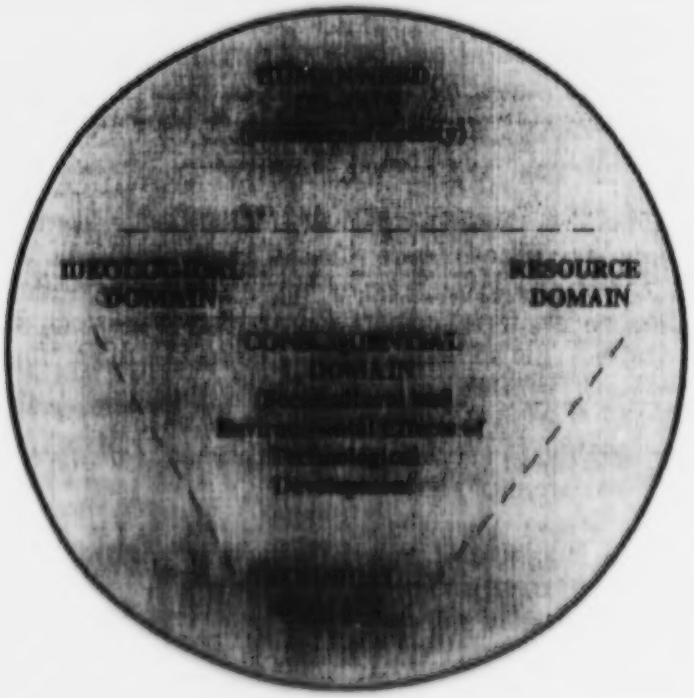
3. The Resource Domain - This domain of activity links both the users and implementors of technology by means of various resources (i.e., people, time, information, materials, capital, tools and machines and energy). The resource domain further provides structure to the technology by controlling various elements of production, communication and transportation.

4. The Technical Domain - This includes the knowledge of tools, materials, processes, systems and techniques in the solving of problems.

5. The Consequential Domain - This domain of activity exhibits the consequences or direct effects (both positive and negative) of the implemented technology.

Each of these domains of activity is presented graphically in Figure 1. Within this figure, the triangle represents the concept of technological development in meeting human needs. The constraints of human values, control and technical means of this development are represented by the ideological, resource and technical domains.

Figure 1
The Social Context of Technology



Irreversibility of Technological Change

Another important implication for citizens to understand is the irreversibility or finality of technological change. This argument is concerned with the various consequences of technological development. The world view of efficiency has eliminated many simpler and less energy intensive methods of production or consumption. An example of this would be the use of the automobile. Walking is clearly less energy intensive, requires no maintenance, is less harmful to the environment and more beneficial to human survival than the automobile. Yet, the automobile is considered more efficient in the overall scheme of productivity. It allows the individual greater freedom, time and speed in transportation. Thus, the automobile is used as a primary mode of transportation for people, goods and services. Wik (1967) has also illustrated this concept of irreversibility of technological change by reviewing the introduction of gasoline tractors and the mechanization of agriculture. In 1800, a farmer needed 344 human-hours of work to grow 100 bushels of corn. In 1910, only 147 hours were required, and by 1960, a farmer could achieve the same result in four hours. Wik noted that such advances were a direct result of the technology being developed and applied to farming. It should further be noted that as newer technology was implemented, the older practices of using horses and mules to cultivate fields were abandoned. In 1917, there were 28 million horses and mules in the United States of America. By 1965, the number of horses and mules had declined to less than 2 million.

Interaction Between Technology, Society and Culture

While the concept of irreversibility can be demonstrated in numerous technologies involving communication, production, transportation and energy utilization, it can be further demonstrated that the implementation of a particular technology is not limited to its initial purpose. This cross-over or integration effect to other areas of society further demonstrates the degree to which technology influences human life. The telephone, for example, was originally designed for voice transmission. It has more recently been integrated with computers that allows the transmission of digital data exchange. Such integration now exists at local, national and even global levels with regard to the fax, car phone, cellular phone, electronic mail, voice mail and satellite communication. Black and Whitney (1988) note that the integrated system of telecommunication technology will do more to change the social structure of society than other previous communication media. The authors further indicate that such changes in America's loss of a sense of community and a stronger emergence of the 'me' generation could result from such technologies as video text and teletext.

Technology and the World Environment

Any consideration of human needs, wants and desires presumes that there is an active means by which to improve the quality of people's lives. This implies dealing with values in our educational programs. Clearly, improvements in the social and economic conditions of life are needed. Development should be continued to be promoted in both the industrialized and emerging countries, but it is further necessary to find a balance between the utilization of our natural resources and economic growth.

This means that education must promote and lead to the rational utilization of technology and the earth's resources. Since this is linked with the concept of sustainable development, one of the objectives of an educational program should be to demonstrate how a concern for the improvement of the environment can be fostered and implemented through the application of appropriate technology and sustainable development. The words appropriate and sustainable are important, since technology has often been used to foster development that leads to the extinction of species, the exhaustion of natural resources and the deterioration of the world environment. Boyer (1986) illustrated the detrimental effects of technology on the world environment:

> Environmental degradation is commonplace throughout the world in both industrial and relatively non industrial countries. Environmental impacts have risen exponentially since World War II as industrial development, molecular chemistry, and high consumption, high waste, throw-away economics have flourished.
>
> The magnitude of modern ecocide [the destructive effects of economic activities on the biological life support system] is becoming planetary, degrading the ozone layer of the ionosphere, carrying pollutants through all the oceans of the world, and producing enough heat from combustion and the hothouse effect in the atmosphere to warm the planet. Small increases in atmospheric temperature can melt polar ice caps, raise ocean levels, alter weather, and create deserts in place of rich farmland. Deforestation is changing weather, altering water supplies, producing deserts, and carrying topsoil

from mountains into rivers and oceans, depleting nutrients for future forests and contaminating the breeding grounds of fish. Excessive extraction of water from aquifers is depleting and poisoning water supplies. Non industrial countries are rapidly following industrial nations in deforestation, while the plant life needed to absorb the worldwide increase in carbon dioxide and to produce oxygen is being reduced. The carbon dioxide increase comes mainly from petroleum through automobile internal combustion engines. But the overriding form of ecocide that can lie ahead is nuclear, radioactive waste from nuclear power plants and massive radioactive contamination and destruction of the protective ionosphere from nuclear war. (pp. 10-11)

Individual Decisions

It is evident that the world is no longer a series of tribes or villages that can operate as independent societies. Technological and economic decisions or the lack of them can have considerable effect on people, the environment and numerous plant and animal species. The consequences from the use of technology are extended socially, morally, environmentally and geographically throughout the world. Moreover, the initial technology developed and implemented may bring with it many secondary effects (both beneficial and harmful) which were unintended when developed. While a new drug or industrial process may lift the burdens from humanity, what are the long term social consequences of such intervention? In the medical field doctors have demonstrated some success in treating diseases from the fetal cells of unborn babies. The question for humanity is, should this technology be advanced on the merits of potentially saving lives?

To answer such a question will require a re-thinking of the relationships between technology and society, individual decision-making and politics and technical development and ethics. The public must become re-educated about the impact of technology on the quality of life, the effects of technology on the local and global environment, and the implications of introducing technology from industrialized to non-industrialized countries.

The public must further recognize that we are both the object and subject of the technological and developmental process. As such, we cannot avoid the ethical decision-making process. The major issues regarding 'progress' are not technical, but human questions involving choices and values. The development of technology only makes sense if society directs this development for the attainment of basic human needs as well as those of knowledge, security, respect and a sustainable future.

The decisions of individual citizens are paramount to this process of change. Education must foster citizens of action who are aware of their democratic responsibilities and can make intelligent political judgments related to controversial issues. The public needs to be educated to the kinds of futures that are actually possible. This will require more citizenship education in schools with an emphasis on planning solutions for the technical and social problems that confront society. Equally important will be an understanding of the means to responsible and effective use of political power. The liberal arts education with an emphasis on understanding cultural differences and unity, the operation and structure of social institutions, scientific and technological knowledge, moral

and ethical development and global dependence offer the best hope of attaining the sustainable, just and humane society.

Impacts of Technology Outline

Technology as a Factor in Social, Cultural and Environmental Change
- Science and Technology Defined
- Social Context in Which Technology Operates
  - Human Need Domain
  - Ideological Domain
  - Resource Domain
  - Technical Domain
  - Consequential Domain
- Technology as a Defining Characteristic of a Society
  - Use of Tools, Artifacts, Materials and Processes
- Dependency of Technological Systems in Meeting Basic Human Needs
  - Food
  - Clothing
  - Shelter
  - Health
  - Security
  - Meaningful Work

Irreversibility of Technological Change
- Accelerating Rate of Change
- The Power of Contemporary Technology
- Centralization and Economics of Scale
- Selected Case Studies
  - Communication
  - Production
  - Transportation/Energy

Interaction of Technology, Society and Culture
- Cross-over and Integration Effects
- Wants and Desires to Perceived Needs
- The Limits of Growth
  - Population
  - Resources
- Impacts of Technology, Society and Culture
- Cost/Benefit Analysis of Technological Development
- Selected Case Studies
  - Communication
  - Production
  - Transportation/Energy
  - Biotechnology

Technology and the World Environment

- Preservation of Species
  - Why do Species Matter?
- Preservation of Resources
  - Resource Rights - Land, Water and Minerals
  - From Consumption to Use - Conservation Strategies
- Sources of Energy
  - Soft Energy Paths
  - Transition Strategies
- Cost/Benefit Analysis of Technological Development
- Sustainable Development
  - Integrated Planning
  - Setting Goals and Priorities
  - Developing Action Plans
  - Citizen Involvement and Action

Individual Decisions

- Technology and Ethics
- An Alternative View to Progress
- An Alternative View to Efficiency
- Civic Responsibility
  - Local Level
  - State Level
  - National Level
  - International Level

Activities

1. Compare and contrast or debate the social, ethical, and legal issues related to such controversial issues as genetic engineering, population control, computers as instruments of human control, and computer access to personal data.

2. Visit a plant or animal breeding center and determine the social and environmental consequences of monoculture farming or breeding.

3. Compare and contrast the methods of high-tech agriculture with those used by farmers practicing sustainable agriculture methods.

4. After contacting a credit reporting agency and obtaining a copy of the records being kept on you, determine their accuracy and the steps necessary should a correction be required.

5. Review case studies on gender equity issues related to the use of computer technology. Debate the ethical issues of computer monitoring and treatment of employees.

6. Use one of the commercial available computer simulations that illustrate urban development and local planning. Evaluate the effectiveness of this simulation as a modeling tool.

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Systems

Introduction

Technology has moved from the industrial and scientific vernacular to the global tongue. Many industries have concluded that the citizenry should be literate about technology. To meet this challenge, public schools and post-secondary institutions are offering or requiring general courses in technology, liberal arts courses with a technology focus, and/or general education curricula with a technology focus. An understanding of *systems* is necessary for a useful understanding of technology. This section defines systems and explores systems concepts as they relate to technology.

Everything is part of numerous systems. Nothing exists or functions in isolation. Everything has an environment. System is another name for environment. Humans are unique in the extent to which we have adapted to the natural and created our own environments. Our human culture is defined by the ideological, sociological, and technological systems which we have created. If the liberal arts exists to teach us about ourselves, our culture and our environment, then technology must be studied as a liberal art. Due to its inherent systemic nature, to understand technology, one must understand systems.

Definition of System

If the layperson is asked to define a system, the response is likely to be in terms of things. For example, a communication system might be comprised of telephones, cables, satellite dishes, and other hardware. However, a system is more than things. At its simplest level, a system is a set of things that have relations to each other.

At this level it is important to understand that to be a system at least two things, parts, or entities must be present. Secondly, the parts must be related or interact in some way. A system always has two distinct yet related populations of characteristics. One population is summative --characteristics that can be classified according to their quantity and or type; the other is constitutive--characteristics classified according to their relation. Consider a married couple as a spousal system. This system contains two parts and the interaction of the two.

At a more complete level of description it can be said that a system is a set of things that have relations to each other and the whole. To use the previous example, the spouses have a relationship to each other but also to the marriage. The union itself can be considered an entity. Now, consider children. Every member of this family system has a relation to every other member and to the whole. Furthermore, every possible subgroup of parts (including the individual) has a relation to every other possible subgroup and the whole. It is evident that relations grow at a different rate than do parts. When it is considered that any two parts or subgroups may exhibit numerous relationships, it is obvious that relationships are what make systems complicated.

To gain a workable understanding of systems, a final element needs to be added to the previous definition:

A system is a set of things that have relations to each other and the whole and that collectively behave differently than when separated.

If the stomach is removed from the digestive system or the automatic teller machine is added to the banking system, the system is not the same. If to system {A} part {B} is added, the result is not system {A+B} but system {C}; a different system is created. It is important to realize a system is not explained by the aggregate of its parts. Any number of analogies could be formulated. However, it is axiomatic that in a system the whole is more than the sum of its parts. This is not to say that all things with two or more parts are systems or that thinking about them as systems has any utility. A pile of rubbish is a heap, not a whole. If the heap is added to or taken away from, the heap is only changed by its aggregate quantity; its characteristics have not been otherwise changed.

A system is a set of things that have relations to each other and the whole and that collectively behave differently than when separated. A system is a set; it has more than one part. However, systems are not only about parts; they are also about the interaction of parts. These two populations of characteristics, parts and interactions, are always present in a system. The parts are summative and are classified according to their quantity and/or type; the interactions are constitutive and are classified according to their relations. The summative components of a system may be physical entities, processes, or constructs. The constitutive components include connections and relationships that may or may not be causal.

The number of parts to a system can range from two to infinity, as can the number of relations. However, a system usually has more relations than parts. Every part or group of parts in a system will have a relation to every other possible grouping. Additionally, system elements can exhibit relationships with other components (including the whole) that include the element itself. However, unlike traditional variance partitioning models, the variance sum of such relationships is greater than that explained by the aggregate of the individual elements. The concept that the whole is greater than the sum of its parts is central to the understanding of systems. Furthermore, every possible combination of parts may have numerous relations. It is evident that relationships are what make systems complicated.

Systems are often easier to describe than to define. Kindred (1980) lists the following characteristics of systems:

1. Made up of different parts

2. The parts are related, have definite reactions and interdependencies

3. A change in one part is likely to cause a change in the other parts and the system as a whole

4. The parts all work toward some purpose or function which is the primary object of the system

5. Usually complex having many types of inputs, processes, outputs, and/or impacts

6. Usually part of a larger system

7. Usually made up of subsystems

8. An infinite number of relations exist among a system, its parts, and other systems.

Related Terms

The following terms are often used in conjunction with systems. Their specific meaning and relation to systems is often ambiguous. Also, an acquaintance with these terms will aid the reader in comprehending systems literature. Therefore, brief definitions of words pertaining to systems are presented.

1. Bifurcation - bifurcate means to divide. The term is used in conjunction with systems to describe a point where the system might change (in parts or relations).

2. Entropy - used in its thermodynamic context referring to capacity for change. Increase in entropy is movement toward stasis and decrease in free energy. The term is also used to describe the disorder of a system. A system with more order is more complex. When systems writers describe disorder they are referring to increase in entropy. Complicated, evolving, bifurcating systems are moving toward higher levels of order and less entropy.

3. Process - used to describe the action or throughput part of the process model, that is, input, throughput (process), and output. The model is referred to as cybernetic when a feedback loop is added to sustain and control the model. Many systems, such as technology, function according to a process or cybernetic model.

4. Stasis - used to refer to motionless but capable of change. The term is also used to refer to ultimate thermodynamic motionless where all energy is expanded and no more work can be done.

5. Synergy - behavior of whole systems unpredicted by the behavior of their parts taken separately (Fuller, 1975).

6. Systemic - viewing or treating things as systems, pertaining to systems in thought or action. This term is often confused with systematic which means having a procedure to follow.

7. Systems thinking - thinking using systemic or systems theory. Systems theory is a multidisciplinary approach that tries to explain the world in the context of wholes--not isolatable causal relationships.

Laszlo (1972) relates that systems theory seeks to discover common features in terms of shared aspects of organization. Laszlo further explains that:

> each system has a specific structure made up of certain maintained relationships among its parts, and manifests irreducible characteristics of its own. If we want to know more about them, we have to treat them as systems, that is, as wholes with properties of their own. That way we can find out something about them - how they behave under various conditions, how they evolve or decay, what parts or subsystems have controlling influence within them, and so on. It is quite unfeasible to come to know these things by considering the specific interactions of each of their individual parts; there are too many of them. (1972, p. 12-13)

What Should Be Known About Systems

There is a lot to be known about systems. Because of their complexity, many can never be fully understood. However, there are certain things about systems in general that most people can learn. This knowledge can help individuals and groups to understand and interact with the systems with which they come into contact.

Types of Systems

Systems can be categorized many ways. It should be kept in mind that categories are human inventions. The appropriateness of a categorization depends on its usefulness to the one doing the categorizing. Systems can be thought of as being:

1. Closed - (the final state is unequivocally determined by initial conditions); or open - (the final state may be reached from different initial conditions).

2. Stable - (at or near equilibrium); or unstable - (far from equilibrium).

3. Sustainable or unsustainable.

4. Natural - (maintains itself through energies available in the environment); or artificial - (obeys law of entropy and must be purposely maintained).

5. Cause controlled - (pro or preactive control); error controlled - (reactive control); or not controlled.

6. Hard - (physical); or soft - (idealized, conceptual, or abstract).

7. Actual (could be physical or conceptual) or nonexistent - (though perceived to be actual). What isn't known didn't bother Will Rogers "but what we think we know that j just ain't so."

Interaction With Systems

Systems are useful not only as conceptions of what exists but also what has existed and will exist, including what humans will create. Systems can (and depending on

the viewpoint sometimes should) be designed, developed, implemented, managed, evaluated, modified, terminated, studied and modeled.

The summative characteristics of a system can be studied in isolation using traditional disciplinary approaches, however, a system's constitutive characteristics cannot be. Systems experts such as Ackoff (1974) point out that structurally systems can be broken down into parts but functionally they are indivisible wholes. Ackoff points out that the world, including systems, is not compartmentalized into disciplines. Therefore, systems must be approached holistically using multidisciplinary methods. Due to their nature, systems have to be observed and experienced to be understood. The investigator needs tactile involvement with the system to gain a complete understanding. This is especially true with process dominated systems such as technology.

Systems and Technology

One of the major systems in our society is the technological system which can be defined at the macro level and micro level, and which is supported by many subsystems.

Technology and Evolution

Technology throughout history has acted in an evolutionary manner. Several systems behave this way; they grow and become more complex. All evolutionary systems share certain characteristics. One commonalty is that they cycle through chaotic and stable states. Although the timing of these alternating states may be random, their outcome is not. It has been empirically found that the outcome of bifurcation's during chaotic states are biased. As Laszlo (1986) reports:

> The statistical average is biased toward the creation of structures that store more energy for a longer time, maximizing free energy and minimizing entropy. Without such a bias, evolution would be a random drift between more and less organized states, instead of a generally one-way build-up of order and complexity through alternating phases of order and disorder, determinacy and indeterminacy. (p. 277)

From the proceeding, Laszlo (1986) extracts two important factors of historical, including technological, change. These are:

> the statistically irreversible increase of free energy in society (with the corresponding increase of complexity and decrease of entropy); and the alternation of comparatively long epochs of stasis with increasing frequent periods of revolutionary transformation. The former testifies to the general direction of historical development; the latter to its dominant mode. (p. 281)

Technology and Other Systems

It is significant to note that in addition to being an evolutionary system, technology creates bifurcation's in other systems. Technology, being one of the major systems of human adaptation, interacts with many other systems. Along with ideological and sociological systems, technology defines the human culture. All three of these systems

and their plethora of subsystems interact with each other and other systems, such as the environment, in an infinite number of ways.

Technology and Subsystems

Systems can be conceptualized as necessary. However, every subsystem is a system in its own right. Every system whether divisible or part of a larger system is a whole. Therefore, no system is an aggregate of other systems (Churchman, 1971). Often systems are divided into smaller systems to allow for a more detailed examination. This may or may not be of benefit. As a conceptualization moves from the general to the specific, more is described about its parts and less about relationships with other things. Conversely, as systems become larger and more general, more is understood about relations of parts and other systems and less about individual parts. Therefore, when studying or designing systems, consideration of the relative importance of parts and relationships is necessary. Depending on the needs of the individual or group, any of the systems in the following hierarchy may be a useful conceptualization:

1. Machine - sheet metal press.
2. Processing or product department - body panel department.
3. Factory - the Saturn automobile plant.
4. Corporate network - GM.
5. Product industry - automobiles.
6. Manufacturing.
7. Production.
8. Technology.
9. Human activity.

Hierarchies are often useful. However, components of a system, whether a discreet part or a subsystem, are not confined to one system. The factory, for example, is also a part of building, societal, and economic systems. Any part can belong to any number of systems.

Technology and the Future

In the long run, technology can be expected to attain ever higher levels of complexity. Its exponential growth rate is well documented. Daily, technological advances that not so long ago were thought impossible or were undreamed of are being brought to fruition. The influence of technology on human existence is tremendous. Furthermore, technology's interaction with other systems is becoming increasingly evident. Consider the rapid changes in the political world which can be attributed to changes in communication technology. All of these changes make for interesting study. Clinically, bifurcation's can be cataloged and states of growth and stasis can be documented. However, for the typical citizen, bifurcation translates into change, which is something not always easy or pleasant to deal with. Higher levels of complexity coming at a faster and faster pace means more and more complicated things to understand and interact with. If the past and the present are any indication of the future, it can be assumed that technology will become more important, that it will grow more complicated, and that change will come ever faster. Because technology's overriding systems

characteristics are unlikely to change, it makes sense that those who have to interact with technology (which is everyone) should be literate about it. Learning how to deal with things and relationships systematically will help individuals to cope with technological and other systems.

Systems Section Outline

Everything in our society operates as part of one or more systems.

- Definitions
- Human interaction with systems
- Types/structure/models of systems
  - Process or input/thruput/output/feedback model.
- Disciplines dealing with systems
  - biology
  - business education
  - computers, engineering
  - sociology
  - technology education
- Common buzz words
  - systems technology
    - degree program, mainly taught by science, math or engineering
  - systems engineering
  - office systems
  - systems management
- Creating and managing systems
- Examples of systems
  - Management system
  - digestive system
  - church system
  - ecological system
  - judicial system
  - democratic system
  - ignition system
  - technological system
  - health care systems

Technological system

- Macro level systems
  - Ideological
  - Sociological
  - Technical
- Subsystems
- Views
- Complexity
  - General direction of evolution is towards complexity
  - Technology is an evolutionary process
    - Changes in
      - society

ideology
culture
environment

Activities for Systems

It is difficult to do an activity that is solely about systems. This is because systems are about relations of parts. The relations and parts are best studied as they pertain to the impacts, influences, and interactions that they have with other systems (relations and parts) in history, the present, and the future. Remember, a system can be physical or perceived. Examples given are that only and not meant to restrict the teacher or student.

Activities

1. Describe/define systems in general and identify specific examples of systems. For example: an electrical circuit, the Internal Revenue Service, or a set of pulleys or gears.

2. List, diagram, and/or model the parts of a system. For example: the plumbing in a house, a lawn mower engine, or judicial system.

3. List, diagram, and/or model the relationships of a system. For example: supervisory/authority relationships in a company, the forces acting on a gyroscope, or the relationship of electrical force, resistance, and current.

4. Hypothesize, test, and/or discuss what happens when you change the parts of a system. For example: add carbon to iron, take guns from policeman, or substitute microwave ovens for convection ovens.

5. Hypothesize, test, and/or discuss what happens when you change the relations of a system. For example: have a supervisor's pay based on the rating the supervisor's workers give him or her, what if medical doctors were voted into their position?, or what if private ownership of VCR's was not legal?

6. Select some thing (relation or part). Brainstorm, list, and/or discuss how many different systems to which the part belongs or the relation exists. For example: money, morals, or the mail carrier.

7. Select a system. Place this system in a hierarchy. That is, list the systems that are part of the selected system. Also, list the systems of which the selected system is a part. For example: the financial system, the phone system, or a dialysis machine.

8. Compare systems (historical, contemporary, future). What were/are/will be the impacts of these systems? For example: the feudal system, the military system, or organized religion.

9. Make a list of systems that work especially well, are dysfunctional, and/or don't work. What can/should we do about them? For example: world-wide food distribution, education, or the penal system.

10. Fix a system. Provide or have the student identify a broken (part or relation) system. Fix/restore the system. For example: an old car, a computer program with bugs in it, or deficit spending.

11. Design a system. For example: a system to teach values to children other than using existing societal systems; an interplanetary transportation system; or a totally integrated communications, entertainment, and information system.

12. Manage or control a system. For example: drive a car, balance your checkbook, or dispose of waste with minimal environmental damage.

Annotated Bibliography

Ackoff, R. I. (1974). Redesigning the future: A systems approach to societal problems. John Wiley and Sons: New York. Focuses on systems as "wholes". Makes the case that compartmentalized disciplines cannot teach about systems--an interdisciplinary approach is needed. Uses the societal system as a frame of reference.

Churchman, C. W. (1971). The design of inquiring systems: Basic concepts of systems and organization. Basic Books, Inc.: New York. Looks at ways to conceptualize systems. Also discusses how parts, relations, and whole systems can be part of a hierarchy of systems and how they can belong to many different systems. Takes an information management point of view.

Fuller, R. B. (1975). Synergetics. Macmillan: New York. Most of the book is mathematical based. Does an excellent job of describing synergy - the concept that a whole is more than the some of its parts.

Kindred, A. R. (1980). Data systems and management: An introduction to systems analysis and design. (2nd ed.) Prentice Hall: Englewood Cliffs, New Jersey. Provides examples of non-hardware systems. Contains much information describing systems.

Laszlo. E. (1972). The systems view of the world. George Braziller: New York. Both this book and the following article explain in understandable language the characteristics of systems. The book shows the utility of viewing the world around us as a system.

Laszlo, E. (1986). Technology and social change: An approach from nonequilibrium systems theory. Technological Forecasting and Social Change. 29 (3), 271-283. This article explains that, due to their systemic nature, society and technology should be expected to change ever more rapidly and grow more complicated.

Johnson, J. R. (1989). Technology: Report of the project 2061 phase 1 technology panel. American Association for the Advancement of Science: Washington, DC. Explains the inter relatedness of mathematics, science, society, and technology. Calls for an integrated approach to teaching the same.

Future Studies

Introduction/Rationale

To participate in a study of the future is to experience pure process, for the outcome, or the product is not as relevant as the ideas, the steps, or the procedure for looking at this time frame. Generally, people need help in doing this well, just as we need help in getting a better understanding of history or a better perspective on the present.

We all have an interest in the future, whether for the next few minutes by an infant or for the next several generations as expressed by the Native American philosophy. Yet we all give too little thought to it. We can choose much of our future world. It is this element of choice that should inspire us to become better at it. The one choice we do not enjoy is to continue to live in an unchanged world. Much has been written concerning the rate, the direction and the challenge of change. This unit will help people "handle" change and a future.

This will generally be a new experience for young people in their formal schooling. Since schooling is, by nature, so process oriented, it may take a little time for them to get comfortable with this future orientation. When they do this will become a valuable and relevant process to transfer to other personal and professional situations; and isn't that what education is all about!

Concepts/Ideas

This will be a sort of primer, to try out some ideas and concepts that relate to the future time frame. Many of these are fundamental to working on the projection techniques for they relate to attitudes that are necessary in making decisions and getting the feel of a projection.

- Rules for future studies
  - -the future can be shaped
  - -many alternative futures exist
  - -there are consequences for every decision
  - -it is possible to distinguish between desirable and undesirable futures

- A very long time ago in the future
  - -It is better to think of time as cyclical not as a straight line

- Old people plant trees
  - -It may be that we can only function into the future as far back as we have a working knowledge

- Everyone has an idiosyncratic pair of glasses
  - -This should add a tentativeness and an openness to all the projections

- Single life span vs. an ever-renewing society

-One of the problems some people have relating to the future is that their focus is too narrow (one plant) rather than a broader perspective (whole garden) which will provide a more realistic vision or impact of an event.

- Think globally/act locally
  -The media is so full of negative news that one can get cynical and discouraged, even though better informed about the world. To counter this negative aspect a local and more personal experience in doing something positive about a problem will provide a better balanced outlook on the future.

- The specter of the powerful outside
  -Most dramatic changes come about through the influence of outside forces. This is true of individuals as well as institutions.

- The law of unintended consequences
  -This concept will keep people a bit humble, for many times it is the unexpected result that is the most lasting.

- Time frames
  -The past is in the analysis mode. What went wrong?
  -The present is in the reaction mode. What is wrong?
  -The future is in the synthesis mode. How to make it go right?

- Everyone is a futurist
  -We all make plans for future expectations.

- The future is lurking in the present
  -It is relatively easy to connect the past and the present into the future, but with hindsight, it is there!

- Develop a future screen
  -Everyone has a variety of screens to filter the input from their senses. One of these screens should have a future orientation to it.

- Have a vision
  -"Without a vision....". This is true today, and for everyone.
  Schools should help young people clarify their vision and increase their commitment to achieve it.

Many of these ideas can be affirmed by the past experiences of people and then applied to future projections.

Projection Techniques

The techniques used as examples here are a few of the more simple ones that are used. These are explained more fully in other references (see bibliography) as are more

complex techniques. The material here should provide you with enough information to decide if you want to learn more about it in order to teach it or use it.

Goal Setting

A consistent factor in a person's success is the setting of goals. This will help a person clarify priorities and to add commitment to a vision which results in a self-fulfilling prophecy. There is no one magic series of steps to guarantee success, but the following series is a good place to start (Tracy, 1989).

1. Set a goal you desire.
2. Must believe you can achieve it, and be challenging.
3. Write it down in detail.
4. How will you benefit?
5. Analyze where you are now.
6. Set a deadline.
7. What are the obstacles to overcome?
8. Knowledge required to achieve the goal?
9. People whose cooperation you will need?

Remember:

- students generally will not be familiar with this exercise
- be sure this goal is a challenge to the student
- will need to be continually fine-tuned

Future Wheel

This research tool uses divergent thinking to produce alternative possibilities through cause and effect linkages. Only events are noted in the circles, and as many levels may be generated as deemed necessary to explore the events which may occur as a result of the initial or central event.

Remember:

- only events in the circles
- review events by saying for each sequence, "If I earn a full time salary, what will happen from that event?"
- scan the outside circles to see the contradictions and variety of events that may result from one change.
- do not list alternatives

Figure 2
Future Wheel

Scenarios

A scenario is a "story" written to enhance the awareness of one particular situation while examining implications and relationships. This is always written from a future point of view, with an emphasis on consequences and ramifications of the topic chosen. The scenario is a projection technique to synthesize a variety of trends and to present a "whole" picture, rather than a narrow analysis that may happen when using some other techniques.

Scenarios are:
- memories of the future
- stories that give meaning to events
- a connection between present and future

- dealing with the world of reality (facts) and the world of perception
- helping people deal with complexity

In preparing to write a scenario, you should consider the nature of the plot of your story. This could be:

- winners and losers
- challenge and response
- evolution
- revolution
- cycles

Ideas to include in the story may come from:

- science and technology
- fringes of events or behavior
- remarkable people
- sources of surprise
- perception shaping events

Some titles of the stories could be:

- My Retirement Speech
- Fifty years of transportation as seen from 2040
- One Hundred Years in the Environment
- Prices I've Had to Pay
- Stories I will Tell My Grandkids

Remember:
A scenario is an easy technique to understand, but a very difficult one to complete. This will take a good imagination, coupled with some logic, and writing ability to express the message and the vision the writer has of a future. This may vary in length from one page to a short story length.

Relevance Tree

This forecasting method directs the planner to a specified future goal through a series of inter-connected events. The desired future goal is identified in advance. Then the main goals and times are put in proper sequence leading to the desired future. Branches or sub goals are identified in the same manner which are necessary to achieve the goals on the main line.

Remember:

- all times and goals flow toward the main goal
- describe the goals and times so they be checked off when completed
- can check on any date to see if they are ahead or behind schedule
- may need other people to check over goals if this is a new experience

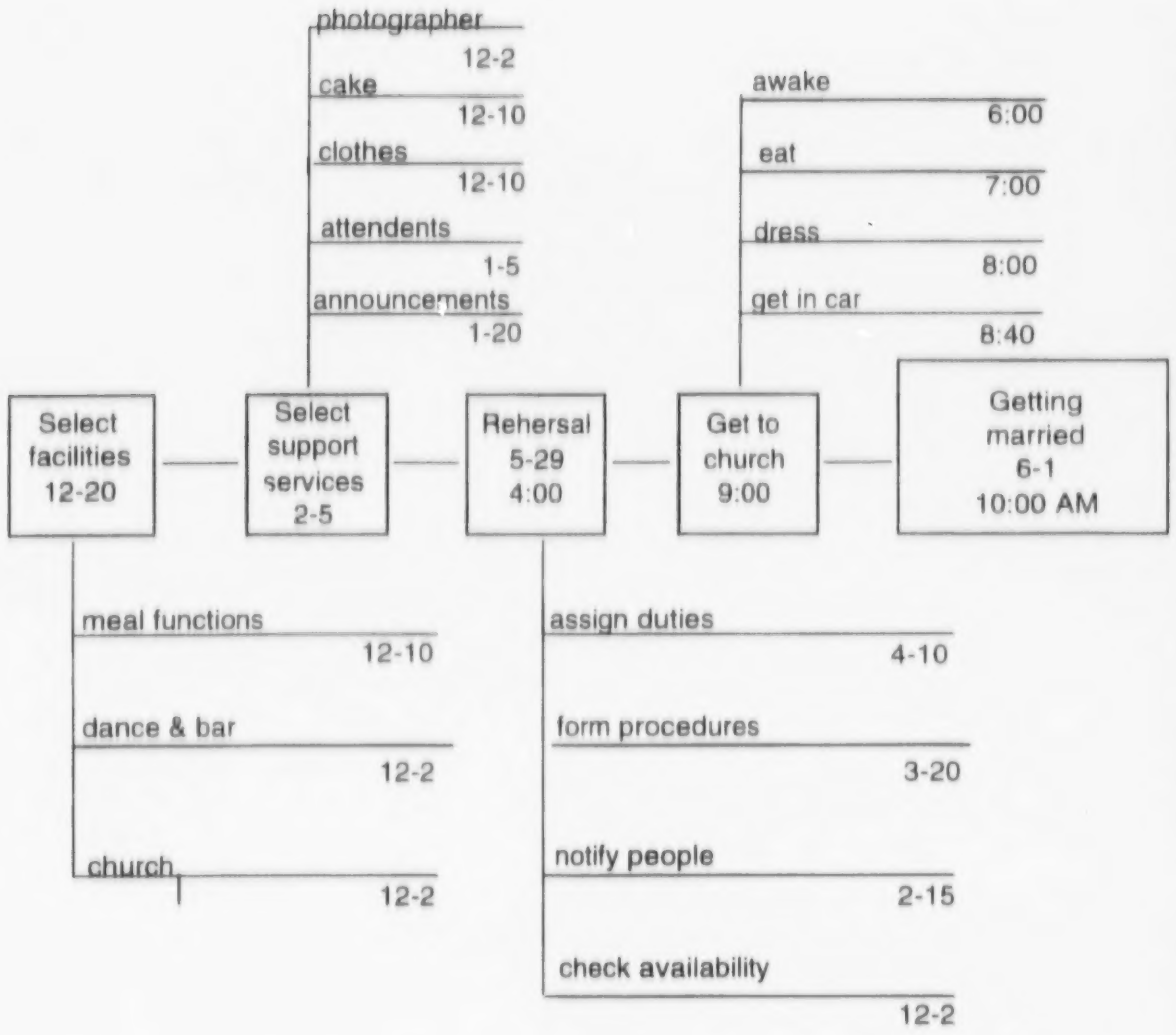

Figure 3
Relevance Tree

Trend Extrapolation

To do this type of forecast there must be available some quantifiable historical data, such as enrollments, salaries, prices, population, volume, etc. This data is then put into a graph and forces are identified that have kept the trend in tension. This means there were forces pushing up so that the data didn't fall straight down, as well as forces pushing down so that the data didn't go straight up. To this point this is all present and history but the extrapolation comes in when this trend, and the forces, are projected into the future. There may be new forces acting in the future, or the older historical ones may still be

operating. There will need to be some judgment made as to the relative projected strength of the forces, which when combined with any new forces will determine if the trend goes up or down.

There are many different patterns that this data may take, and the futurist must be capable of a clear analysis of historical data or the extrapolation will be worthless.

Remember:
- get "hard" data
- identify forces historically that account for trends
- let the projected data flow from the projected force strengths

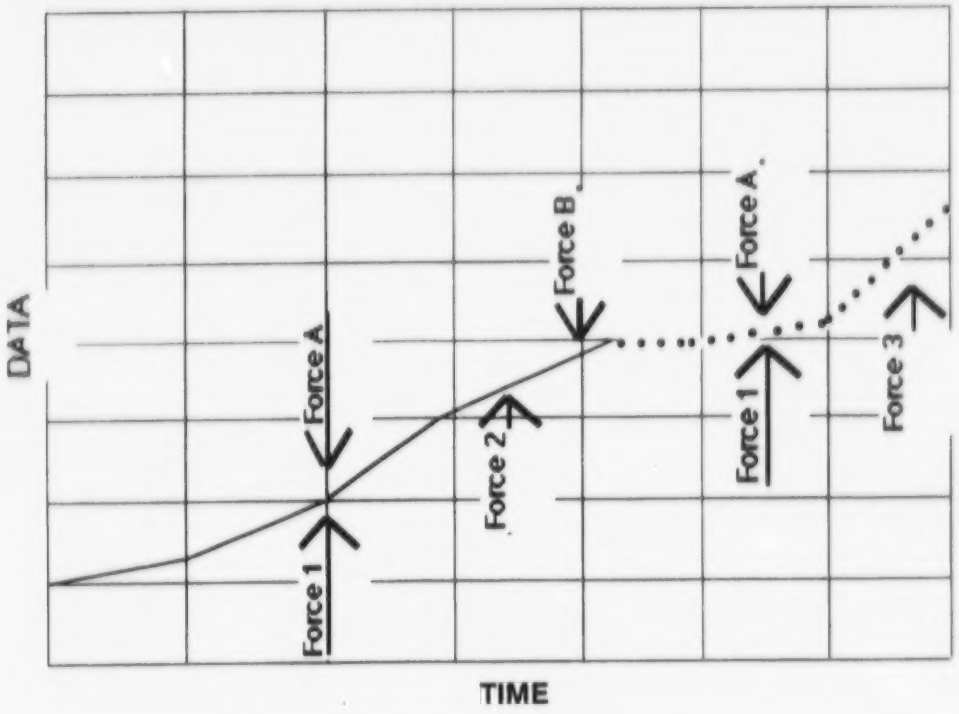

Figure 4
Trend Extrapolation

Other Projection Techniques

Some of the other techniques you may wish to consider in addition to or to substitute for one of the previous examples:

- Delphi Probes
  An attempt to get consensus through repeated questionnaires and feedback as to other's positions.
- Cross-impact Analysis
  An analysis of impacts of a particular future, where elements are judged on their inter-relatedness.

- Intuition
  A rarely used thinking process that accounts for some insight that is complete and true.
- Precursor
  When a country, institution or person has consistently gone through experiences prior to another's emergence of the problem.

Future Studies Outline

Rationale

The payoff for present thinking and planning will be in the future. Since few college students will have had formal instruction relating to a future, his unit should be a challenge to learn new concepts and techniques in how to handle probable technological futures. It will also open up a new area of literature for many of them.

Objectives

After completing this unit, students will:

- Use and implement a process of setting goals
- Employ common projection techniques to project a technological future
- Appraise possible technological futures that others propose
- Formulate goals of a sustainable technological future and illustrate how their activities will help contribute to the success of these goals.

Outline:

Goal setting process
Set a goal you desire.
Must believe you can achieve it, and be challenging.
Write it down in detail.
How will you benefit?
Analyze where you are now.
Set a deadline.
What are the obstacles to overcome?
Knowledge required to achieve the goal?
People whose cooperation you will need?

Common projection techniques

Scenario These are memories of the future, not about predicting the future, but about perceiving futures in the present, in a story format that gives meaning to events.

Relevance Tree A forecasting method that directs the planner to a specified future goal through a series of interconnected events along a time line, generally with branches to indicate relevant times and events that are necessary for success.

Trend Extrapolation After a trend is established visually, with data on a graph, forces are identified which keep the trend line in tension. The strengths of these forces are then projected into the future and the line restructured according to the projected trend.

Future Wheel The thinking process here is to identify the cause and effect relationship between a central event, entered into the center of the wheel, and the second order consequences. The second order consequences are then used as causes for the third order consequences, and this process goes on.

Sources of Possible Technological Futures

- Science fiction literature
- Newspaper articles
- Magazine articles
- Books
- Individual interviews

Outline/Activities

In order to pull some of these ideas and techniques together, the following unit outline will allot 18 one hour periods for future studies.

Future Studies Unit

Day	Topic	Teacher Activity	Student Activity
1	Introduction	explain unit and assignments	
2	Concepts & ideas	explain	provide examples
3	Projection techniques	explain	
4	Resources available	provide examples	
5	Goal setting	instruct	
6	Practice	feedback	have example
7	Trend extrapolation	instruct	
8	Practice	feedback	have example (small group)
9	Relevance tree	instruct	
10	Practice	feedback	have example (small group)
11	Future wheel	instruct	
12	Practice	feedback	have example
13	Scenario	instruct	
14	Practice	feedback	have example

15	Oral reports	projections	own & others
16	Oral reports	projections	own & others
17	Test		
18	Review	synthesis	synthesis

Activities

1. Goal setting

After selecting a challenging and relevant goal, complete the nine steps in the suggested sequence. Your remarks should show some insight into the difficulties this goal will provide and your commitment to the successful achievement of the goal.

2. Trend Extrapolation

In a small group (3-5) you will project some historical data such as the telephone or television, after an analysis of the forces that created the trend. This will be done in graph form, with no narrative needed to explain the configuration of the data. Or chose a current technology and project its trend into the future.

3. Relevance Tree

In a small group (3-5) you will complete a relevance tree to graphically show the goals and times that need to be completed in order to successfully achieve a main goal. This should have several branches that reflect the sub-goals that need to be achieved.

4. Future Wheel

You will complete a future wheel, where each event has a cause and effect relationship with others that are connected. The logic should be evident between these events.

5. Scenario

You will write a future story, with a message and a vision, of some aspect of life (for example, the field of communication, transportation or medicine) at least 20 years from now. This story, at least three pages long, will bring together a variety of changes and have implications for people living now.

6. Oral Reports

You will report, in class, on either one of your own projections or else a projection that someone else has made and reported on in the media or the literature. This report will include your assessment of the probability of its accuracy.

Annotated Bibliography

Coates, J., Jarratt, J. and Mahaffie, J. (1990). Future work. San Francisco: Jossey-Bass. An excellent reference for identifying forces that are reshaping work and the work force. Is also set up to be used as a text.

Cornish, E. The Futurist. Bethesda, MD.: World Future Society. Published bimonthly by the World Future Society, included in your membership. (Dues $30.00 per year for individuals) "must" reading for both teachers and students.

Didsbury, H. (Ed.) (1989). The future: Opportunity not destiny. Bethesda, MD.: World Future Society. This is one of a series of books prepared in conjunction with the World Future Society's international assembly. Wide variety of topics and difficult to retrieve.

Grun, B. (1979). Timetable of history. New York: Simon and Schuster, Inc. This is a valuable resource since an understanding of history is necessary for relevant projections. Seven areas from politics to daily life are linked to people and events from 5000 BC to 1978.

Hardison, O., Jr. (1989). Disappearing through the skylight: Culture and technology in the 20th century. New York: Viking. A very readable book, with some "wild" implications drawn from a wide variety of sources. Will loosen up your thinking about the possibilities in the future.

Longstreet, W. and Shane H. (1993). Curriculum for a new millennium. New York: Allyn and Bacon. The authors focus on the design and implementation of a curriculum in order to keep pace with the changes in our society. Suggestions range from simple seating arrangements to a complex reorganization of schooling.

Meadows, D. H., Meadows, D. L., and Randers, J. (1992). Beyond the limits. Post Mills, VT. : Chelsea Green Publishing Company. This is the sequel to the 1972 The limits To growth, but not much more optimistic. Lots of data involved and they do allow for a transition to a sustainable system. You don't have to agree, but they should be heard.

Moorcraft, S. (Ed.) (1993). Visions for the 21st century. Westport, CT. : Praeger. Generally short pieces of a general nature by people in "high places". Not recommended for light reading.

Morrisey, G. (1992). Creating your future: Personal strategic planning for professionals. San Francisco: Berrett-Koehler. Excellent help for the goal-setting exercise. There are worksheets, checklists and charts to help in planning for success in both the personal and professional area.

Meyers, N. (1990). The gaia atlas of future worlds. New York: Doubleday. A review of environmental implications from current forces plus changes that can improve the world by the year 2000. Lots of pictures for an easy read.

Naisbitt, J., and Aburdine, P. (1990). Megatrends 2000: Ten new directions for the 1990's. New York: Wm. Morrow. Not nearly the "punch" of his original Megatrends but is still important to read on this global level.

Schwartz, P. (1991). The art of the long view. New York: Doubleday. The focus of this book is on the "long view" through writing scenarios. You will not only learn how to write scenarios better but also get some ideas for a better vision of the future.

Time: Beyond the Year 2000. (1992). New York: Time Inc. Look for these special issues of periodicals for they will present many topical issues that will provide much discussion.

Tracy, B. (1989). Psychology of achievement (cassette recording). Chicago, IL. : Nightengale-Conant Corp. This is one of several self-help messages that may provide some ideas for students and teachers as it focuses on success.

Whaley, C. (1984). Future studies: Personal and global possibilities. New York: Trillium Press. This is the best, single reference book for those just beginning in the futures field. Especially good for the introduction to projection techniques. Only 103 pages.

Zuboff, S. (1988). In the age of the smart machine. New York: Basic Books. Interesting, insightful look at the implications of some present trends in the work place, for both labor and management. Typical is her quote, "To put it simply, learning is the new form of labor."

SAMPLE TOPIC

Artifact	GENETIC ENGINEERING Potential topics for discussion
History	Mendel's law and plant genetics Animal genetics and cross-breeding Discovery of DNA and genes Research in recombinant DNA Biological engineering The history of these processes and their relationships to each other.
Impacts	Commercialization of human, plant, or animal reproduction Prenatal/neonatal screening, including sex preselection Invitro fertilization Genetic surgery to eliminate disease Embryo transfer to surrogate mother Fetal tissue transplantation
Systems	Description of the function of the parts and the relationships of genetic engineering and with other systems with which the genetic engineering is a part or has a relationship.
Future	The potential futures that can result from using genetic engineering positively or negatively. For example: Cloning The release of lethal biotechnical products into the biosphere Guaranteeing a "perfect" child

SAMPLE TOPIC

Artifact	COMPUTER Potential topics for discussion
History	Abacus Babbage's analytical and difference engines Jacquard and Hollerith and the punched card Aiken and the Mark I computer ENIAC Development of the transistor Microelectronics/microprocessors Personal computers
Impacts	The current impacts, influences, and interactions of computers on: manufacturing communications third world development money, banking and trade societal values political systems
Systems	Description of the functions of the parts within a computer, and their relationships with other systems with which the computer is a part or has a relationship
Future	The future of computer components and their relationship to other technologies Future trends in computers Future worlds influenced, directed, led by computers

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